

Coalition for Urban Rural Environmental Stewardship
PROJECT PLAN / RESEARCH GRANT PROPOSAL
CDFA FERTILIZER RESEARCH & EDUCATION PROGRAM

A. Cover Page

1. Project Title

Evaluation of the Multiple Benefits of Nitrogen Management Practices in Walnuts

2. Project Leaders

Parry Klassen: Project Director/Principle Investigator (PI), Coalition for Urban Rural Environmental Stewardship (CURES), 1480 Drew Ave. #130, Davis, CA 95618, 559-288-8125, pklassen@unwiredbb.com

Allan Fulton: Co-PI, University of California Cooperative Extension Division of Agriculture and Natural Resources Tehama County, 1754 Walnut St., Red Bluff, CA 96080, 530-527-3101, aefulton@ucanr.edu

3. Project Cooperators

Alan Reynolds: Board Chairman, East San Joaquin Water Quality Coalition, 1201 L Street, Modesto, CA, 209-394-6200, alan.reynolds@ejgallo.com

Joseph McGahan: Executive Director, Westside San Joaquin River Watershed Coalition, 559-582-9237, jmcgahan@summerseng.com

Bruce Houdesheldt: Executive Director, Sacramento Valley Water Quality Coalition, 916-442-8333, bruceh@norcalwater.org

Michael Wackman: Executive Director, San Joaquin County & Delta Water Quality Coalition, 916-684-9359, michaelkw@msn.com

4. Supporters

Parry Klassen: Chair, Management Practices Evaluation Program Group Coordinating Committee (MPEP GCC), 1201 L Street, Modesto, CA, 559-288-8125, pklassen@unwiredbb.com

Doug Parker: Director, California Institute for Water Resources, University of California Agricultural and Natural Resources, 1111 Franklin St., 10th Floor, Oakland, CA 94607, [510-987-9124](tel:510-987-9124), doug.parker@ucop.edu

Adam Laputz: Assistant Executive Officer, Central Valley Regional Water Quality Control Board, 11020 Sun Center Drive, #200, Rancho Cordova, CA 95670, 916-464-4726, Adam.Laputz@waterboards.ca.gov

Renee Pinel: President and CEO, Western Plant Health Association, 4460 Duckhorn Drive, Suite A, Sacramento, CA, 95834, 916-574-9744, reneep@healthyplants.org

David Ramos, Ph.D.: Production & Post-Harvest Research Consultant, California Walnut Commission, 101 Parkshore Dr. Ste. 250, Folsom CA 95630, 916-932-7070, deramos@ucdavis.edu

5. CDFA Funding Request Amount/Other Funding

Funding requested from California Department of Food and Agriculture, Fertilizer Research and Education Program: \$109,381.20 (2015/2016), \$81,362.30 (2017), and \$34,250.40 (2018) for a total of **\$224,993.90**. Central Valley Irrigated Lands Regulatory Program Third Party Groups (CV Coalitions) have pledged funds for this project however due to the timing of this proposal an exact amount could not be determined at this time. It is anticipated that each Coalition will be able to contribute \$5,000 (\$5,000 in 2016 and \$5,000 in 2017) per year as well as in-kind

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services in the form of technical review and member outreach. The pledge needs to be confirmed by each respective board of directors in March 2015.

Alan Reynolds: Board Chairman, East San Joaquin Water Quality Coalition, 1201 L Street, Modesto, CA, 209-394-6200, alan.reynolds@ejgallo.com; **ESJWQC Contribution: \$10,000**

Joseph McGahan: Executive Director, Westside San Joaquin River Watershed Coalition, 559-582-9237, jmcgahan@summerseng.com; **WSJRWC Contribution: \$10,000**

Bruce Houdesheldt: Executive Director, Sacramento Valley Water Quality Coalition, 916-442-8333, bruceh@norcalwater.org; **SVWQC Contribution: \$10,000**

Michael Wackman: Executive Director, San Joaquin County & Delta Water Quality Coalition, 916-684-9359, michaelkw@msn.com; **SJCDWQC Contribution: \$10,000**

6. Agreement Manager

Parry Klassen: Coalition for Urban Rural Environmental Stewardship, 559-288-8125, pklassen@unwiredbb.com, 1480 Drew Ave. #130, Davis, CA 95618

B. Executive Summary

1. Problem

Nitrate is a major contaminant in Central Valley groundwater and elevated levels are attributed primarily to leaching of nitrogen fertilizers past the root zone. Growers who belong to Central Valley Water Quality Coalitions (CV Coalitions) are under new requirements per the Irrigated Lands Regulatory Program to keep “on farm” a Nitrogen Management Plan (NMP) to track nitrogen fertilizer applications. A key component of the NMP is reporting nitrogen consumption during the growing season with the assumption that the remaining nitrogen is lost to groundwater. Determining crop consumption is one of several requirements of the Management Practices Evaluation Program (MPEP) that five CV Coalitions are cooperatively implementing (East San Joaquin Water Quality Coalition, Westside San Joaquin River Watershed Coalition; San Joaquin County and Delta Water Quality Coalition; Sacramento Valley Water Quality Coalition; Westlands Water Quality Coalition). The MPEP has specific objectives including identifying management practices that are protective of groundwater quality, determining whether newly implemented management practices are improving or may result in improving groundwater quality, developing an estimate of the effect of Member’s discharge of nitrate on groundwater quality and utilizing the results to determine whether practices need to be improved. There are data gaps in understanding the effectiveness of management practices on reducing the amount of nitrate transported through the root zone of walnuts. This project will document the amount of nitrogen applied and the movement and distribution of nitrate from the point of application through the root zone in 2 walnut orchards. This project will evaluate the movement of nitrogen through the root zone during rain and irrigation events over a two year period.

2. Objectives, Approach, and Evaluation

Objective 1: Identify the management practices being implemented to reduce the amount of nitrogen moving through the root zone for Orchard 1 and Orchard 2.

Approach: Fields will be identified with the assistance of the cooperating CV Coalitions and the California Walnut Commission. Management practices implemented by growers will include split fertilizer applications (based crop load and UC/industry expertise on optimal timing), and testing of soils/irrigation water/petiole-leaf to better understand crop nitrogen need and the amount of nitrogen and nutrients needed for optimal production. In addition, both orchards will

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use microsprinkler irrigation as a management practice to reduce the potential for leaching. Measurements will be collected over two years (two storm seasons and two irrigation seasons). Note: exact management practices beyond those listed will be determined once cooperator(s) have been identified. Two years will be necessary to ensure that the nitrogen measurements are repeatable from year to year and the study includes annual variability in weather and pest pressures. The BMPs will be implemented for at least two years allowing for changes in yields as a result of the BMPs and full evaluation of leaching potential.

Evaluation: Management practices for nitrogen fertilizer applications and irrigation timing will be identified for both fields prior to the implementation of the study. Throughout the two year study, practices performed by the grower such as nitrogen applications and irrigation events will be recorded. Total yield and root zone nitrate results will be compared over the two years to account for the effect of the implemented BMPs on the amount of nitrate leaching and changes (if any) in yield.

Objective 2: Determine the amount and timing of nitrogen moving through the root zone.

Approach: The study will be conducted in 5 acre plots in two different fields. The fields will be located within the cooperating CV Coalition boundaries (Madera County north to Shasta County). Each field will be sampled in the winter following adequate rain to saturate soils and throughout two irrigation seasons. Samples will be collected from:

- Lysimeters to evaluate the amount of nitrogen in the water moving through the root zone;
- Soil to evaluate the amount of nitrogen in the soil;
- Irrigation water to evaluate the amount of nitrogen in water used during irrigation that is in addition to fertilizer applications;
- Crop tissue at appropriate time intervals including harvest.

Soil permeability will be measured with a constant head permeameter during each of the three time periods (sets) during both years of the study. Permeability will be measured at the same time that soil samples are collected. Permeability measurements will be used to assess the heterogeneity of the field with respect to soil hydraulic conductivity. Tissue samples, including the roots (where possible) will be collected at randomly selected locations in each field throughout the growing season. Samples will be collected from the lysimeters after winter rain events to better determine the movement of residual nitrogen in the soil as a result of rain.

Evaluation: Data collected from the field studies will be recorded in an electronic database, analyzed and summarized in interim and final reports. The reports will evaluate nitrate leaching in the two fields. Results will be placed in the context of previous studies on nitrogen leaching in walnuts.

Objective 3: Identify the multiple benefits of nitrogen management practices implemented in Orchard 1 and Orchard 2 including potential cost savings (reduced water costs, reduced amount of money spent on fertilizer) and groundwater protection (reduction in the amount of nitrogen that is moving through the root zone).

Approach: Costs for implementing the practices will be quantified for each individual management practice. Elements to be evaluated include: cost of water, cost of fertilizer applications, labor costs, and additional costs for practices such leaf, water and soil analysis. The benefit of protecting groundwater will be estimated by using the information obtained regarding the movement of nitrogen through the root zone.

Evaluation: The costs of implementing identified management practices will be quantified and the benefit of protecting groundwater will be estimated. The evaluation of these benefits will be included with outreach materials to encourage growers to implement similar practices.

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Objective 4: Determine if additional practices could be implemented to further reduce the amount of nitrogen moving past the root zone.

Approach: Once the amount and timing of nitrogen moving through the root zone is determined, the range of management options can be evaluated to determine if it is possible to reduce nitrogen moving past the root zone. The range of management options will be identified with the assistance of Allan Fulton of UC Davis Cooperative Extension (Co-Principal Investigator) and Dr. David Ramos of the California Walnut Commission.

Evaluation: An analysis of management options will be performed after the two year study with the assistance of the California Walnut Commission, crop specialists with UCANR, CDFA and other experts in walnut production and included in the final report.

Objective 5: Disseminate results to growers of walnuts.

Approach: Walnut growers will be provided the results of this study through the Outreach component of this project. Field Days will be conducted during the study time period to demonstrate the management practices implemented; these will be scheduled once the project is approved for funding. In addition, at the conclusion of this project and summary write up will be provided to the CV Coalitions for use in coalition member outreach.

Evaluation: During the Field Days, the participants will be surveyed to determine the effectiveness of the demonstration. The number and types of outreach materials will be recorded.

3. Audience

Initially walnut growers and their crop advisors, water quality coalitions, UC Extension Farm Advisors, State and Regional Water Quality Control Boards and the FREP program are the target audience for knowledge gained from this project. Eventually the results of this project and other CURES' related projects will also be relevant and beneficial to growers with many annual crops in California's Central Valley. The information will help guide the selection of practices used by members of CV Coalitions who are required to use nitrate management practices known to minimize contamination of groundwater with nitrates and be compliant with groundwater protection regulations. Study results will help fill knowledge gaps and identify benefits to growers who implement multiple nitrogen management practices including better understanding of the efficacy of these practices in protecting groundwater resources while maintaining expected crop yield potential and quantifying cost savings.

C. Justification

1. Problem

Elevated levels of nitrate present in groundwater in Central Valley locations are being attributed, in part, to inputs from farming practices. The Central Valley Water Board estimates that approximately three million acres of irrigated lands overlay groundwater aquifers that have high levels of nitrogen or are vulnerable to nitrate contamination. In the Central Valley, approximately 33,000 landowners/operators are affected by the new ILRP requirements to implement practices to protect groundwater. Similar groundwater issues are problematic in other regions of California as well. The objective of the NMP and the MPEP is to better manage and understand the amount of nitrate that is leached to groundwater when Best Management Practices (BMPs) are implemented while also assuring that these processes are indeed effective. This project will document the uptake of nitrate fertilizer by the walnut crop and the movement and distribution of nitrate through the root zone in a walnut orchard. The resulting data will

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assist FREP, growers, water quality coalitions, Western Plant Health Association (WPHA), Certified Crop Advisors, UC Extension Farm Advisors, and the state and regional Water Boards in understanding nitrogen behavior, movement and distribution as fertilizer moves through the soil. Additionally, the results of this study can be used in the other agricultural areas of California where groundwater contamination with nitrate is of critical concern.

2. FREP Mission and Research Priorities

This study supports FREP's goals of filling the information gap in the understanding nitrogen behavior, movement and distribution as it moves from the point of application through the soil and past the root zone. The study results will assist with the evaluation and advancement of the environmentally safe and agronomically sound use of nitrogen fertilizers. The data from this project will also be useful, in combination with other research, to support FREP's goal of assessing the quantity of nitrates from nitrogen fertilizers accumulating in groundwater.

3. Impact

The research will provide growers and crop advisors with information needed to quantify the loss of nitrate through the root zone for selected management practices. This information can be used by growers to adjust their management practices and reduce the amount of nitrate lost to groundwater. Additionally, the information generated by this project will help growers optimize their nitrate applications and save money in their farming operation. The BMP recommendations will be vital to walnut growers in the Central Valley, who are an important part of the approximately 33,000 landowners/operators who farm nearly 7 million acres of land and are impacted by the new ILRP requirements to improve nitrogen and irrigation practices to minimize nitrate discharges to ground and surface water.

In addition, the research techniques and protocols developed during this study will be the demonstration to the Regional Board that this study design can be replicated in other locations and with other crops to evaluate the efficacy of management practices. The information generated by this project will be critical in allowing the CV Coalitions to meet the compliance measures outlined in their Waste Discharge Requirements.

4. Long-Term Solutions

Over the long-term, implementation of the nitrate BMPs evaluated by this project will contribute to measureable reductions in nitrate discharges to groundwater, and thereby contribute to the restoration of groundwater drinking water resources. The restoration of groundwater will reduce the regulatory compliance costs of all users of water. In addition, evaluating nitrate BMPs can reduce the economic cost of over fertilization providing growers with a potentially significant cost savings within their operation. Additionally, the reduction of impacts to groundwater reduces treatment costs associated with domestic supply wells which can allow expanded use of lower cost groundwater for domestic uses.

5. Related Research

Research: The management of fertilizer applications can be done only with knowledge of the 4 R's (right time, right place, right source, and right rate) for each crop. Very little is known about the 4 R's for most of the crops grown in the Central Valley. Studies are just beginning to be performed to develop nutrient budgets and optimum fertilizer management in walnuts. DeJong

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et al. (2014¹) determined that depending on variety and location, approximately 25 – 30 lbs N/ton (1% - 1.5%) is removed in harvested biomass (nuts and hulls) in walnut orchards. However, DeJong et al. found that there was more variability between sites across cultivars than between cultivars. Soil nutrient loss varied spatially from sandy loam to silt loam to clay loam. Early analytical results indicated that soil variability was high even within a small portion of an orchard but initial results showed leaching of nitrate as early as late July and increasing towards the end of the season with heavy precipitation events. Leaching did not appear to occur during the growing season due to the limited movement of water below the root zone.

There is little other research being conducted although there is some work on carrots (Allaire-Leung et al. 2001²) and some recent work has been performed using tomatoes (e.g., Hartz and Hanson 2009³, Hartz and Bottoms 2009⁴). A majority of the research involves evaluating practices that optimize the use of applied N. Hartz and Hanson (2009) reported that conventionally-irrigated tomatoes need 100 – 150 lbs of nitrogen per acre because there is an additional substantial contribution from residual soil NO₃ and from the mineralization of organic N in the soil during the growing season.

Hartz and Hanson (2009) and Hartz and Bottoms (2009) reported:

- Early season NO₃-N analysis of soils can guide application rates during the growing season,
- Nutrient uptake (including P and K in addition to N) is slow until fruit set begins and then accelerates significantly,
- The majority of the accumulation of N occurs between flowering and fruit maturity,
- Nutrient uptake slows significantly in the last weeks before harvest and it is unnecessary to apply fertilizer during this period (right time),
- Several smaller fertigation events during the period of rapid uptake are optimal (right rate and right place),
- Leaf N analysis early in the growing season is the best measure of nitrogen status and can provide an indication of the nitrogen sufficiency status of the crop.

Although Hartz and Hanson (2009) and Hartz and Bottoms (2009) reported that leaching of N from drip irrigated tomatoes should be low during the season, estimates of in-season leaching are not available and it is not clear how much NO₃ may be lost from the root zone during the winter season.

Dr. Patrick Brown and his colleagues have developed a significant amount of information about the 4 R's in the context of minimizing leaching of nitrate to groundwater in almonds and

¹ DeJong, T. K. Pope, P. Brown, B. Lampinen, J. Hopmans, A. Fulton, R. Buchner, and J. Grant. 2014. Development of a nutrient budget approach and optimization of fertilizer management in walnut. Walnut Research Reports, California Walnut Board

² Allaire-Leung, S. E., L. Wu, J. P. Mitchell, and B. L. Sanden. 2001. Nitrate leaching and soil nitrate content as affected by irrigation uniformity in a carrot field. *Agricultural Water Management* 48:37-50.

³ Hartz, T. and B. Hanson. 2009. Drip irrigation and fertigation management of processing tomato. University of California Vegetable Research and Information Center. 11 pgs.

⁴ Hartz, T. K. and T. G. Bottoms. 2009. Nitrogen requirements of drip-irrigated processing tomatoes. *HortScience* 44:1988-1993.

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pistachios (e.g. Hopmans et al. 2010⁵). Dr. Brown and Mr. Fulton are currently involved in research projects with walnuts that are addressing the loss of nitrate through the root zone although those projects are in their early stages and no results are widely available. Although permanent crops are very different from annual crops, there does appear to be commonality in the results of research on N use in annual crops and almonds including:

- The concentration of nitrate in the fertigation system during a fertigation event influences the efficiency with which N is used. Root nitrogen uptake is also influenced by previous nitrate inputs to the system and suggests that providing small amounts of nitrate over time are more efficiently used compared to larger applications (right rate).
- The majority of the accumulation of N occurs between flowering and fruit maturity,
- Nutrient uptake slows significantly in the last weeks before harvest and it is unnecessary to apply fertilizer during this period (right time),
- Leaf N analysis early in the growing season is the best measure of nutrient status and can provide an indication of the nutrient sufficiency status of the crop.

In addition to the research cited above, CURES has conducted research in walnuts in an orchard near Stockton. Although one of the major aspects of that research was to identify a reliable method of sampling nitrate below the root zone, additional information was collected on the effectiveness of a “right rate” management practice. Briefly, thirty suction lysimeters were placed in an orchard and samples were collected after each irrigation event throughout the irrigation season. Sources of nitrate included irrigation water, nitrate applied during fertigation, residual soil NO₃-N, and mineralized N. The orchard experienced some leaching of nitrate below the root zone as measured by the concentration of nitrate in water collected in lysimeters located below the roots (CURES report to CDFA in preparation).

Outreach: For over 15 years, CURES in collaboration with academic, commodity, professional, regulatory and non-profit organizations, has been instrumental in testing the efficacy of BMPs for improving water quality and facilitating widespread implementation and adoption of BMPs and Integrated Pest Management (IPM). CURES has produced numerous publications on BMPs for reducing off-site movement of sediments, nutrients and pesticides to surface water, irrigation management practices and practices for supporting healthy populations of pollinators, and assembled region-specific collections of these technical bulletins in binders entitled “BMP Handbook,” with distribution to approximately 7,500 growers, PCAs, and agricultural organizations in the Central Valley. The BMP publications and the results of water quality related BMP studies are posted on CURES website: www.curesworks.org. Additionally, by utilizing a group of experts participating in the MPEP effort, the contribution will be from a broader base and in the process educate those in the agricultural community who are less likely to be knowledgeable about nitrogen research and options.

CURES project leader, Parry Klassen, has extensive experience in production agriculture. Mr. Klassen also serves as Executive Director of the East San Joaquin Water Quality Coalition. This organization represents more than 3,900 landowners in Madera, Merced and Stanislaus counties under the Irrigated Lands Regulatory Program. Among other responsibilities, Klassen manages the grower outreach and education programs and also actively participates in CV-SALTS and the

⁵ Hopmans, J. W., M. M. Kandelous, A. Olivos, B. R. Hanson, and P. Brown. 2010. Optimization of water use and nitrate use for almonds under micro-irrigation. Almond Industry Conference, Modesto, CA.

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MPEP effort on behalf of the East San Joaquin Water Quality Coalition.

Bill Jones, CURES' field specialist, has more than 30 years of professional experience in crop nutrition, irrigation water chemistry, and soil fertility management in a variety of crops in California. His recent projects include pre-plant assessments of soil fertility, irrigation water, selection and application of organic amendments, and plant nutrition management on farms in Tulare, Kern, and Fresno Counties.

Allan Fulton, the project's co-PI has more than fifteen years of experience working with orchard irrigation and soil management including evaluating off-site water quality impacts. He has worked with orchard managers on integrated water management concepts and groundwater hydrology.

MLJ-LLC and its principal Dr. Michael L. Johnson and field manager Matthew Zane, bring over 25 years of experience in basic and applied science to problems involving water quality. MLJ-LLC employs several environmental scientists that have experience with similar studies conducted in the Salinas Valley using romaine lettuce. MLJ-LLC staff are available to work on this project at all times as needed and necessary.

6. Contribution to Knowledge Base

Some information is available on the management of nitrate in walnuts with the assumption that proper nitrogen applications (fertigation), use of subsurface drip irrigation, and standard yields results in minimal or no leaching of nitrate to groundwater. However, this has yet to be demonstrated for walnuts and there is little known about potential leaching of nitrate during the fallow winter season. This project will confirm the conclusions made in previous studies of walnut nutrient management and provide growers with the information necessary to come into compliance with their WDRs. In addition, this study will allow the Management Practices Evaluation Program Group Coordinating Committee (MPEP GCC) to develop a template study design that can be used across several orchard crops in the Central Valley.

7. Grower Use

The nitrogen practices implemented during the study will be considered characteristic of what the "early adopters" of that crop are currently using. Most of the practices are already being used widely but not often simultaneously in a field. For instance, drip/microirrigation is widely used in the Central Valley. But drip irrigation, tissue/leaf sampling, split applications of nitrogen, pre- and post-crop soil testing, soil moisture sensors, and other newer practices, may not all be used at once in a single orchard. This project is intended to show that when all the "best" practices for the cropping conditions are used, nitrate movement to groundwater can be minimized/eliminated and, presumably, increased production will cover the cost. Once data are developed on the effectiveness of these practices when used in combination, growers will be motivated to adopt the measures by pressure currently exerted by regulatory agencies to protect groundwater resources. Information will also be provided to growers on the costs of the practices and potential yield or quality benefits that might be expected by their adoption.

D. Objectives

Objective 1: Identify the management practices being implemented to reduce the amount of nitrogen moving through the root zone for Orchard 1 and Orchard 2.

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Objective 2: Determine the amount and timing of nitrogen moving through the root zone.

Objective 3: Identify the multiple benefits of nitrogen management practices implemented in Orchard 1 and Orchard 2 including potential cost savings (reduce water costs, reduce amount of money spent on fertilizer) and groundwater protection (reductions in the amount of nitrogen that is moving through the root zone).

Objective 4: Determine if additional practices that could be implemented in order to further reduce the amount of nitrogen moving through the root zone.

Objective 5: Disseminate results to growers of walnuts.

E. Work Plans and Methods (for multi-year projects, include a work plan for each year)

1. Work Plan

Task 1 – Project Management: Project management will occur throughout the duration of the project to ensure that Tasks 2 – 6 are being completed on time and on budget. This task will ensure that **Objectives 1-5** are met. Project Management will include coordination of the study team personnel including the Co-PI, Project Advisor, Project Cooperators, Project Supporters and the Subcontractor MLJ-LLC. **Task Products** include progress reports and invoices submitted in a timely manner to CDFA. This task will continue throughout the project term.

Task 2 – Grower Identification: The cooperator grower will be identified based on availability and willingness to participate with the assistance of the Project Team in order to meet **Objective 1**. **Task Products** include the recording of management practices implemented to increase the efficiency of nitrogen use including application timing and irrigations. This task will occur prior to the implementation of sampling and during both years of the study. Grower identification will be completed 3 months after project initiation (October 2015).

Task 3 – Study Design: The Study Design will be refined once the cooperator growers and the fields are identified. The **Task Product** is the study design which will include mapping of the fields, review of soil map data to ensure comparability between fields, determination of the grid cells for the sampling and scheduling of sampling. This will be included in the Summary Report. The Study Design is essential for meeting **Objective 2** in combination with Task 4 – Sampling. The Study Design will be agreed upon by the Project Team prior to initiation of sampling of a rain event which is scheduled to occur between November 2015 and March 2016.

Task 4 – Sampling: Sampling will include soil, pore water, irrigation water and plant tissue N. The study will also include permeability measurements in order to meet **Objective 2**. Sampling will occur after a rain event each year (November – March) and approximately 4 irrigation events (this may include a pre-irrigation event). The Sampling Design (Task 3) will refine the sampling schedule in order to meet **Objective 2**. **Task Products** include sample collection and receipt of results from the laboratory/field sampling.

Task 5 – Data Management: Results obtained from sampling (both laboratory and field results) as well as management practice information (details regarding timing and rates of applications) will be recorded in an electronic database. Data will be analyzed to evaluate differences in nitrate leaching between orchards (**Objective 2**) and estimate costs for implementing practices (**Objective 3**). **Task Products** include an electronic database of results to be used for data analysis in the Summary Report. Data Management will begin with the first sample collection (2015/2016) and end with the draft Summary Report (2018).

Task 6 – Summary Report: The Summary Report will include the identification of management practices, sample design, analysis of results, evaluation of nitrate leaching between

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fields, a cost analysis of BMP implementation, identification of additional practices that could be implemented, and documentation of outreach efforts (**Objectives 1-5**). **Task Products** include a draft Summary Report that will be disseminated to the Project Team for comments/edits. A final Summary Report will incorporate comments from the Project Team and submitted to CDFA. Information from the Summary Report will be utilized in outreach materials.

Task 7 –Outreach: Outreach will include Field Day demonstrations and dissemination of results to growers and CV Coalitions. Field Days will be conducted to demonstrate the management practices being implemented and the results from the Summary Report will be distributed to the MPEP GCC and CV Coalitions to meet **Objective 5**. **Task Products** include outreach materials summarizing the conclusions of the study.

Table 1. Work Plan Tasks and Subtasks by Year.

Task / Subtask	Task Products	7/2015 – 12/2015	1/2016 – 12/2016	1/2017 – 12/2017	1/2018 – 6/2018	Completion Dates
1. Project Management	Progress Reports, Invoices	x	x	X	X	June 2018
2. Grower Identification	Agreement with grower	x				October 2015
	List of management practices					
3. Study Design	Study Design	x				December 2015
3.1. Assess Field Comparability						
3.2. Map Sample Locations						
3.3. Determine Sampling Locations						
4. Sampling	Sample Collection /Analysis	x	x	X		January 2018
4.1. Preparation/Cleanup						
4.2. Equipment Installation						
4.3. Sample Collection						
5. Data Management / Analysis	Electronic database	x	x	X	X	March 2018
5.1. Field Data Entry						
5.2. Laboratory Data Review / Entry						
5.3. BMP Cost Estimates						
5.4. Database Management						
6. Summary Report	Draft Report			X	x	March 2018
6.1. Draft Report	Final Report				x	June 2018
6.2. Final Report						
7. Outreach	Outreach Materials		x	X	X	June 2018
7.1. Conclusion Summaries for Outreach						
7.2. Field Days						

2. Methods

Field Characteristics: Two orchards with similar management practices and irrigation systems will be selected in a geographically similar location. Both orchards will be adequately characterized to ensure they meet the necessary parameters of the study. Characterization will include soils, irrigation timing and volume, and irrigation system design. A 5 acre study plot will be selected within each of the two orchards and 15 grid cells will be established in each plot. Field heterogeneity will be addressed by first consulting NRCS soil maps and attempting to locate 5-acre study plots that lie within a single soil type. Depending on the parameter, between

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5 and 15 measurements will be collected. For lysimeters, 15 samples will be collected from each plot during each irrigation event. Further analysis of heterogeneity will be done using statistical analysis on a combination of soil nitrate data and field hydraulic conductivity data developed from permeability measurements. Both irrigation efficiency and irrigation distribution uniformity are important factors determining the spatial variability in the rate at which nitrate moves through the soil. The location of each of the 5 acre study plots will be selected to address these factors. Irrigation timing and volume data at both sites will be gathered using a pulse output water meter and data logger. Soil permeability will be calculated using measurements obtained from a compact constant head permeameter. Soil samples and pore water samples will be collected and analyzed for nitrate to quantify movement through the root zone. Tissue samples will be collected to calculate the amount of nitrogen in various plant tissues. Gross yield data and nitrate results from tissue samples collected at harvest will be used to quantify the amount of nitrate removed at harvest.

Permeability: Each year 10 measurements of saturated hydraulic conductivity (K_{sat}) will be made on each of the 5 acre plots using a compact constant head permeameter (Amoozemeter). Field saturated hydraulic conductivity (K_{sat}) will be measured within 7 randomly selected grid cells at a well depth of 24 inches and a constant head depth of 12 inches.

Soil N: Three sets of 15 soil samples will be collected and analyzed for N each year. The first soil collection will occur prior to any pre-irrigation. A second soil collection will occur approximately half way through the crop cycle. The third set will be collected immediately after the harvest. Soil will be collected from five randomly chosen locations. Using a spoil probe, soil from a single hole will be collected from three depth intervals; 0-24 inches, 24-48 inches and 48-72 inches. Each set of cuttings will be homogenized and transferred to a 4-oz glass container. The samples will be submitted to the laboratory and analyzed for nitrate as N (EPA 300.0) and percent solids (SM 2540G). N mineralization potential will be measure by Solvita soil respiration or water extractable organic C and N. Mineralization potential is necessary to understand the conversion of organic N to NO_3 which then becomes an available source of nitrate for the crop. Samples will be collected at the same time as samples are collected for NO_3 analysis of soil.

Irrigation Water N: Samples of irrigation water will be collected and analyzed for nitrate. Three samples will be collected during the growing season; at the time of initial irrigation, mid-season, and at the time of the final irrigation.

Pore Water N: Suction lysimeters will be used to quantify N concentrations past the root zone. Suction lysimeters will be installed in each grid cell at a depth of 42-44 inches. For each sampling event, a manual suction of 60-75 PSI will be pulled on each lysimeter using a hand pump. Using a syringe, samples will be collected between 16 and 24 hours after suction has been pulled. Samples will be delivered to the laboratory within 24 hours to be analyzed for nitrate as N (EPA 300.0). Samples will be collected during a minimum of three irrigation events and will capture at least one fertigation event. Funding provided by cooperators will be used to sample and capture the remaining irrigation/fertigation events.

Plant Tissue N: Two sets of 10 tissue samples will be collected and analyzed for N content and

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percent moisture each year. The first collection will occur approximately halfway between planting and harvest. The second set will be collected the day prior to harvest. A tree from 10 randomly chosen grid cells within the 5 acre study area will be selected for tissue sampling. Leaf and fruit samples will be collected from each tree. In addition, an attempt will be made to collect root and woody tissue samples from each of the trees. If this is not feasible, previous studies on N content of roots and woody tissue for walnut trees will be evaluated and incorporated into the study.

Data Analysis: Measured parameters (e.g. concentration of nitrate in leachate, plant tissue N, soil residual N, mineralization rate) will be compared between fields using standard statistical procedures such as repeated measures ANOVA. Analyses such as plot characterization will be done with multivariate methods such as Principal Components Analysis. The relationship between the concentration of nitrate leaching past the root zone and other variables such as the amount of nitrate in irrigation source water, fertigation rate will be analyzed graphically because the sample size of 2 (or 3 if possible) precludes statistical analyses. Spatial variability in permeability the concentration of NO₃ in soils and leachate collected by lysimeters will be analyzed using standard spatial statistics.

3. Experimental Site

The study area will consist of two 5 acre blocks; each block will be located in a different walnut orchard located near Chico, CA. The orchards will be selected based on similar management and irrigation practices and both will be irrigated via surface drip. CURES is currently working with UCCE and the California Walnut Commission to identify cooperators. Identification of orchards in which to conduct the study is the first objective of the study.

F. Project Management, Evaluation and Outreach

1. Management

This project, as with the other projects for which CURES is seeking FREP funding, will be managed by a specific project team described below along with oversight by the MPEP GCC and the MPEP Technical Committee (members listed below). CURES is using this project as the pilot for additional studies to be performed over the next several years and these planned studies will also be managed by the MPEP GCC. The MPEP GCC has responsibility to perform studies to demonstrate that management practices used in irrigated crops grown in the Central Valley are protective of groundwater resources. While the project team will have responsibility for the activities and deliverables of this project, the MPEP GCC and its Technical Committee will provide feedback, advice and ongoing guidance to this project. It is expected that the project will be managed using a process that after the first year is completed, may result in adjustments in the study design to ensure that the most accurate and useful information is developed. Any changes to this project would be reviewed and approved by FREP contract managers before they are undertaken.

The project director and principal investigator, Parry Klassen, is Executive Director of the Coalition for Urban Rural Environmental Stewardship (CURES), a non-profit, 501c3 organization. Mr. Klassen has a B.S. in Agricultural Communication from California State University, Fresno, and is a commercial fruit grower in Fresno County. Mr. Klassen has been closely involved with the formation of Central Valley watershed coalitions since 2002 with

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CURES and as executive director of the East San Joaquin Water Quality Coalition. CURES, under the management of Mr. Klassen, has worked in collaboration with academic, commodity, professional, regulatory and non-profit organizations and has been instrumental in testing the efficacy of BMPs for improving water quality and facilitating widespread implementation and adoption of BMPs and IPM. Mr. Klassen and CURES staff will manage this project, facilitate communication and collaboration among the cooperating entities through conference calls and team meetings, ensure that the study goals and objectives are being addressed throughout the project, oversee the field research, deliver outreach presentations, work with the grower cooperator to assist with management practice implementation and study logistics coordination, and gather and compile all supporting materials from collaborators and subcontractors to submit reports, invoices and deliverables to the FREP Grant Manager on time and on budget.

The project Co-PI, Allan Fulton, earned his Master's in Soil and Irrigation Science from Colorado State University, Fort Collins in 1986. Mr. Fulton has more than fifteen years of experience supporting the California walnut industry through applied research and education programs as an Extension Specialist with the University of California. Mr. Fulton will provide oversight and technical support for the research project.

The MPEP GCC is made up of five Central Valley water quality coalitions and encompasses more than 5 million acres of irrigated cropland. The participating coalitions include the East San Joaquin Water Quality Coalition, Westside San Joaquin River Watershed Coalition, the San Joaquin County and Delta Water Quality Coalition and the Sacramento Valley Water Quality Coalition who are all cooperators of this study. The MPEP GCC includes the Executive Directors of each Coalition, a member of each Coalition's Board of Directors, and an alternate for each member of the respective Board of Directors. In 2014, the MPEP GCC formed a Technical Committee to provide oversight and direction to all its crop research projects. The committee is made up of the following individuals:

- Dr. Patrick Brown, UC Davis Department of Plant Sciences
- Dan Munk, UCCE Farm Advisor
- Allen Fulton, UCCE Irrigation and Water Resources Advisor
- Doug Parker, Director, California Institute for Water Resources, UC Agricultural and Natural Resources
- Dr. Rob Mikkelsen, International Plant Nutrition Institute
- Dr. Tim Hartz, UCCE Vegetable Crops Specialist, Department of Vegetable Crops
- Lowell Zelinski, Precision Ag Consulting
- Dr. Gabriele Ludwig, Almond Board of California
- Charles Rivara, California Tomato Research Institute
- Mark Cady, CA Department of Food and Agriculture
- Barzin Moradi, CA Department of Food and Agriculture

The MPEP GCC is working with its Technical Committee to develop a conceptual study design for all its studies performed under the MPEP, including the proposed project. The MPEP GCC contracted with CURES to serve as MPEP Administrator. The MPEP GCC will collaborate with CURES to provide project outreach, and has pledged in-kind funding for this project.

Michael L. Johnson will be responsible for conducting the research guided by the Co-PIs and the

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MPEP Technical Committee. Dr. Johnson is the President and Managing Partner of MLJ-LLC and brings over 25 years of extensive experience to this project. Dr. Johnson spent 26 years as an academic scientist, first at the University of Kansas and the last 18 years were spent as a research scientist at UC Davis. Dr. Johnson has considerable experience conducting research including both field and laboratory studies. Dr. Johnson retired from UC Davis Center for Watershed Sciences in 2010.

2. Evaluation

This study does not include new technologies and barriers to adoption are not anticipated. Throughout the study, practices performed by the grower such as nitrogen applications and irrigation events will be recorded. Data collected from the field studies analyzed and summarized in interim and final reports. Study results will be compared to previously performed studies on the crop. The costs of implementing identified management practices will be quantified and the benefit of protecting groundwater will be estimated. The evaluation of these benefits will be included with outreach materials to encourage growers to implement similar practices. An analysis of management options will be performed after the two year study with the assistance of the California Walnut Commission, crop specialists with UCCE, CDFA and other experts in walnut production and included in the final report. During the Field Days, the participants will be surveyed to determine the effectiveness of the demonstration. The number and types of outreach materials will be recorded.

3. Outreach

CURES, on behalf of the MPEP GCC, will organize multiple outreach efforts throughout and following the two year field trial. The MPEP GCC will promote Field Days in which growers and interested parties are invited to the study site to view the project in process. Once the data gathered during the study are analyzed, CURES will compile a PowerPoint presentation and organize meetings for Coalition members who grow walnuts. These meetings will be held in all of the participating Coalition regions. In addition, each of the participating Coalitions will be provided outreach materials (e.g. presentations, summary results) to include in their Annual Member Meetings. A summary of the project and results will be compiled into a written publication that will be distributed to growers, commodity groups, California crop advisors, and other interested parties. Specific dates for Field Days will be set based on progress of the studies, and the availability of growers and participating CV Coalitions. CURES will update FREP regarding meeting dates as they are set.

G. Budget Narrative

The budget attached in the budget template is based on funds being available as of July 2015. The funds included in the attached budget template include 2015 funds in the 2016 estimate.

a. Personnel Expenses

CURES staff are listed below including the number of hours estimated to work on the study project per year. The Annual Total includes all wages and benefits. CURES staff will manage contracts, invoicing and progress reports and ensure that subcontractors remain on schedule and within budget.

<i>Personnel, Title (% full time)</i>	<i>Hrs/ Yr</i>	<i>Wage/ Hour</i>	<i>10% Benefits</i>	<i>10% Overhead</i>	<i>Wage/ Hour</i>	<i>Annual Total</i>
<i>Parry Klassen, Project Director/PI (2%)</i>	60	\$130.00	\$13.00	\$13.00	\$156.00	\$9,360.00

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<i>Personnel, Title (% full time)</i>	<i>Hrs/ Yr</i>	<i>Wage/ Hour</i>	<i>10% Benefits</i>	<i>10% Overhead</i>	<i>Wage/ Hour</i>	<i>Annual Total</i>
<i>William Jones, Project Manager (4%)</i>	60	\$110.00	\$11.00	\$11.00	\$132.00	\$7,920.00
<i>Clint Phelps, Assistant PM (2%)</i>	60	\$50.00	\$5.00	\$5.00	\$60.00	\$3,600.00
<i>Tamara Watson, Contracts Manager (1%)</i>	24	\$60.00	\$6.00	\$6.00	\$72.00	\$1,728.00
<i>Kara Stuart, Administrative Assistant (3%)</i>	120	\$35.00	\$3.50	\$3.50	\$42.00	\$5,040.00
<i>TBD, Bookkeeper (2%)</i>	36	\$30.00	\$3.00	\$3.00	\$36.00	\$1,296.00

b. Operating Expenses

Supplies: \$300 over the duration of the project is included for office-related expenses including teleconferencing, copies, and document sharing website.

Equipment: All equipment needed for this project will be supplied by the subcontractor(s).

Travel: It is estimated that three (3) CURES staff will travel a total of 5 trips per year (averaging 200 miles round trip @ \$0.56 per mile) which will include lodging (\$90 a night) and meals (\$56 for 3 meals). Travel costs is \$4,000 for 2015/2016, \$4,000 for 2017 and \$2,300 in 2018.

Professional/Consultant Services: Allan Fulton (University of California, Davis) will assist CURES with grower identification and outreach and is budgeted \$2,500 per year to pay for supplies and travel. MLJ-LLC will perform Task 3 (Study Design) through Task 7 (Summary Report) completing the sampling, analysis and report summaries. MLJ-LLC's budget includes personnel (\$98,860), equipment/supplies (\$8,603.50), transportation (\$9,920) and analytical costs (\$29,648) associated with sampling and conducting the field trials. MLJ-LLC will manage data collected as part of this study and work with the Project Team on developing the draft and final Summary Reports.

Other Expenses: No Other Expenses have been identified.

c. Other Funding Sources

As part of their commitment to the MPEP, four CV Coalitions have pledged funds for this project. Due to the timing of the proposal, the pledges are estimated but are expected to be a total of \$80,000 over two years.

H. Budget Template (see attached excel spreadsheet)

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I. Appendices

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Appendix 1: Project Leaders

Resume: Parry Klassen

Executive Director

**East San Joaquin Water Quality Coalition
Coalition for Urban Rural Environmental Stewardship
Central Coast Groundwater Coalition**

Parlier, CA

559-288-8125

pklassen@unwiredbb.com

Education

Bachelor of Science Degree in Agricultural Communications; emphasis in agronomy and journalism. California State University, Fresno, 1981.

Employment History

September 2004 to Present – Executive Director, East San Joaquin Water Quality Coalition.

Manage the activities of this non-profit entity formed to assist members to be in compliance with the Irrigated Lands Regulatory Program. Responsibilities include managing relations with the Regional Water Board and coalition subcontractors and implementing outreach programs on improving water quality in the coalition region. www.esjcoalition.org

August 1999 to Present – Executive Director, Coalition for Urban/Rural Environmental Stewardship. Responsibilities include managing the non-profit organization and working with clients on a variety of research and communications projects. Research projects focus on evaluating management practices to protect surface and groundwater; outreach programs consist of developing publications, organizing meetings, presentation development and performance, media outreach and other communications functions. All projects are performed by forming alliances with various agricultural organizations to achieve the project goals.
www.curesworks.org

January 2012 to Present – Executive Director, Central Coast Groundwater Coalition
Manage the activities of this non-profit entity created to fulfill the groundwater monitoring requirements of landowners and growers located in the Central Coast region of California. Responsibilities include managing subcontractors who perform well sampling and implementing the outreach program directed at 573 members who farm 204,000 acres in the region.
www.centralcoastgc.org

1997 to 2004 -- Communications Consultant, Freelance Writer.

Worked on a variety of communications projects including media relations, issues management, and writing. Projects included copy writing and editing, organizing meetings, presentation development and performance, media outreach and other communications functions. Clients included Crop Life America, Almond Board of California, California Tree Fruit Agreement and other agricultural entities.

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1995 – 1997 – *Communications Manager, Western Plant Health Association* – Manage communications activities for this trade association based in Sacramento.

1981 to 1995 -- Reporter and Editor

Reporter and editor for a number of agricultural publications, including *Farm Chemicals*, *California Farmer*, *Western Fruit Grower*, and *American Vegetable Grower* magazines. Also written extensively about greenhouse and ornamental crops, cotton, and related agricultural subjects.

Farming Background

1991 to present -- Own and operate fruit farm near Parlier.

1988 to 1990 -- Rented peach orchard in Ohio for direct market sales.

1979 to 1980 -- Worked during college on cotton and vegetable farm.

1970 to 1975 – Actively involved in family tree fruit farm in Reedley, CA. Growing, packing, and shipping operation included 150 acres of peaches, plums, nectarines, and vegetables. (Farm sold in 1975).

Resume: Allan Fulton

J. Allan E. Fulton - Irrigation and Water Resources Farm Advisor

University of California Cooperative Extension, Tehama, Glenn, Colusa, and Shasta Counties

Home Contact:

20810 Bare Road, Red Bluff, CA 96080

Home: (530) 527-1018

Cell: (530) – 200 -2246

E-mail: ae Fulton@gmail.com

Employer Contact:

University of California Cooperative Extension

1754 Walnut Street, Red Bluff, CA 96080

Office: (530) 527-3101

E-mail: ae Fulton@ucdavis.edu

EDUCATION

Master of Science, Soil and Irrigation Science, Colorado State University, Fort Collins, CO, 1986

Bachelor of Science, Agronomy, Colorado State University, Fort Collins, CO, 1983

WORK EXPERIENCE

Irrigation and Water Resources Farm Advisor, Tehama, Glenn, Colusa, and Shasta Counties, University of California Cooperative Extension, Red Bluff, CA, 2000 – Present.

Develop, demonstrate, and extend irrigation and soil management practices for orchard and agronomic crops that sustain production, use water efficiently, and prevent off-site water quality impacts. Extend knowledge to water users in the northern Sacramento Valley concerning groundwater hydrology and integrated water management concepts. Educate water users of non-point source water quality regulations facing irrigated agriculture and the role of watershed management approaches to respond.

Managing Agronomist, den Dulk Farming Company, Kingsburg, CA 1997 – 2000. Co-managed 1100 acres of orchard and vine crops and 2400 acres of alfalfa and row crops near

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Hanford, California. Responsible to oversee management of irrigation, soil quality and plant nutrition, and pest management.

Soils, Water, and Winter Grains Farm Advisor, Kings County, University of California Cooperative Extension, Hanford, CA 1986 –1997. Develop, demonstrate, and teach irrigation management practices for orchard and agronomic crops that use water efficiently, reduce agricultural drainage and runoff. Investigate and provide information on soil and water amendments to manage soils with slow water infiltration resulting from irrigation water supplies of lower water quality. Evaluate salt tolerance of agronomic crops, trees, and halophytes. Study blending and cyclical approaches to re-use saline-sodic agricultural drainwater for irrigation. Research and extend knowledge on all agronomic aspects of irrigated wheat and barley production.

RECENT PROFESSIONAL ACTIVITY AND PUBLIC SERVICE

- Past President, California Chapter American Society of Agronomy, 2013/14
- Member of UC ANR Strategic Initiative Panel for Water, Dec. 1, 2011 - Nov. 30, 2013
- Technical editor for Tehama County AB-3030 Groundwater Management Plan Update. 2012
- Chair, Tehama County AB3030 Technical Advisory Committee. 2009
- Current member of the Glenn County Groundwater Technical Advisory Committee since 2001
- California Groundwater Resources Association, Affiliate. – “Groundwater Monitoring: Design, Analysis, Communication and Integration with Decision Making. Invited presenter, February 2009, Conference Speaker, Anaheim, CA

Recent Publications: Allan Fulton

Ayars, J. E., A. Fulton, and B. Taylor. Subsurface Drip Irrigation in California - Here to Stay? Agricultural Water Management Journal. January 2015. journal homepage: www.elsevier.com/locate/agwat.

O' Geen, Anthony, Thomas Harter, Helen Dahlke, Fogg, Graham, Samuel Sandoval, Allan Fulton, Saal, Matt, Paul Verdegaa, Rachael Elkins, Franz Niederholzer, Chuck Ingels, and David Doll. A Soil Survey Decision Support Tool for Groundwater Banking in Agricultural Landscapes. Submission for publication in California Agriculture. October, 2014. Pending peer review.

Fulton, A., J. Grant, R. Buchner, and J. Connell. Using the Pressure Chamber for Irrigation Management in Walnut, Almond and Prune. May 2014. UC ANR Publication 8503. <http://anrcatalog.ucdavis.edu/Details.aspx?itemNo=8503>.

Fulton, Allan. Technical Editor. Tehama County Flood Control and Water Conservation District Coordinated AB 3030 Groundwater Management Plan 2012. pp. 196. November 2012. http://www.tehamacountypublicworks.ca.gov/Flood/documents/2013_GWMP/1_GWMP_TOC.pdf.

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Fulton, A. and the California Department of Water Resources, Northern District. Northern Sacramento Groundwater Newsletter Series (thirteen issues). April 2003 – June 2011.
http://cete.hama.ucdavis.edu/Agriculture/Groundwater_Management.htm

Stewart, William, Allan Fulton, William Krueger, Bruce Lampinen, and Ken Shackel. A five-year study of Regulated Deficit Irrigation (RDI) in almond: Reducing consumption on a low water holding soil. California Agriculture. April-June 2011, Vol. 65 No.2 pp 90-95.

Fulton, Allan, Larry Schwankl, Kris Lynn, Bruce Lampinen, John Edstrom, and Terry Prichard. Using EM and VERIS technology to assess land suitability for orchard and vineyard development. Journal of Irrigation Science. DOI 10.1007/s00271-010-0253-1. December 2010.

Fulton, A., B. Sanden, and J. Edstrom. Soil Evaluation and Modification. Chapter 7. Prune Production Manual. Buchner, R. P., Editor. University of California, Agriculture and Natural Resources. In-Press. . July 17, 2010.

Fulton, A. and B. Sanden. Salinity Management. Chapter 6. Prune Production Manual. Buchner, R. P., Editor. University of California, Agriculture and Natural Resources. In Press. July 17, 2010.

Long, Rachael., Allan Fulton, and Blaine Hanson. Protecting Surface Water from Sediment-Associated Pesticides in Furrow-Irrigated Crops. Publication 8403. University of California, Agriculture and Natural Resources. March 2010. Pp. 16.

Long, Rachael F., Blaine R. Hanson, Allan E. Fulton, and Donald P. Weston. Mitigation techniques reduce sediment in runoff from furrow-irrigated cropland. California Agriculture. Division of Agriculture and Natural Resources. University of California. Vol. 64. No. 3. Pp. 135-140.

Buchner, R.P., Fulton, A., Gilles, C., Lampinen, B., Shackel, K., Metcalf, S., Little, C., Pritchard, T. and Schwankl, L. "Effects of Regulated Deficit Irrigation on Walnut (*Juglans regia*) Grafted on Northern California Black (*Juglans hindsii*) or Paradox Rootstock." Proceedings 5th International Symposium on Irrigation of Horticultural Crops. Mildura, Australia. January 2007.

Lubell, M. and A. Fulton. Local Policy Networks and Agricultural Watershed Management. Journal of Public Administration Research and Theory. Advance Access published November 4, 2007.

Current Projects, Time Commitments and Impacts on Proposed Project – Allan Fulton

Project Title or Creative Activity/ Duration	Role (PI, Co-PI, etc.)	Collaborators (with affiliation)	Support Source
Almond Water Production Function Research	Provide oversight of Tehama County field experiment. Work routinely with grower cooperator. Impose irrigation treatments, oversee field assistant and collection of water, crop development, and yield data. Involved in data analysis and reporting to Almond Board of California.	Ken Shackel, Professor, Plant Sciences, UCD, David Doll, UCCE Farm Advisor, Merced County, Blake Sanden, UCCE Farm Advisor, Kern County, and Bruce Lampinen, UCCE Statewide Extension Specialist	Almond Board of California

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Project Title or Creative Activity/ Duration	Role (PI, Co-PI, etc.)	Collaborators (with affiliation)	Support Source
Evaluating Physiological Indicators of Early Season Water Stress in Walnut	Provide oversight of Tehama County field experiment. Work routinely with grower cooperator. Impose irrigation treatments, oversee field assistant and collection of water, crop development, and yield data. Involved in data analysis and reporting to Walnut Research Board.	Ken Shackel, Professor, Plant Sciences, UCD and Bruce Lampinen, UCCE Statewide Extension Specialist	California Walnut Research Board
Evaluation of water use and crop coefficients in mature walnuts.	Co-PI. Arranged two orchards to conduct experiment, routinely maintain instrumentation and collect field data. Involved with data analysis and extension of results.	Richard Snyder, Co-PI, UCCE Specialist, Cayle Little, Co-PI California Department of Water Resources, and Richard Buchner, Farm Advisor, UCCE, Tehama County	California Department of Water Resources and Tehama County
Evaluation of water use and crop coefficients in French Prune.	Co-PI, Arranged one orchard to conduct experiment, routinely maintain instrumentation and collect field data. Involved with data analysis and extension of results	Richard Snyder, Co-PI, UCCE Specialist, Cayle Little, Co-PI California Department of Water Resources, and Richard Buchner, Farm Advisor, UCCE, Tehama County	California Department of Water Resources and Tehama County
UC-ANR Web-based Irrigation Scheduling and Nitrogen Management Tool for California Crops	Leader in the development of modules and algorithms that expand UC ANR's Crop Manage web-based irrigation scheduling to almond and walnut orchard crops.	Michael Cahn, UCCE Monterey County, and Khalid Bali, UCCE, Imperial County.	California Department of Water Resources
Nitrogen Management Training for California Certified Crop Advisors (CCA's)	Served on a UC ANR Steering Committee chaired by Water Strategic Initiative Leader, Doug Parker. Committee developed curriculum for a 1 1/2 day training and certification session on nitrogen management in irrigated agriculture. I co-authored and presented curriculum related to irrigation management and its interaction with nitrogen management and I contributed to the development of an interactive training exercise on nitrogen management decision making.	Doug Parker, UC ANR Water Strategic Initiative Leader, Patrick Brown, Professor Plant Sciences, Tim Hartz, UCCE Statwide Vegetable Crops Specialist, Stuart Pettygrove, UCCE Emeritus, Larry Schwankl, UCCE Emeritus, Dan Munk, UCCE Farm Advisor, Fresno County, and others.	California Department of Food and Agriculture

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Resume: Michael L. Johnson, LLC

530-756-5200

mjohnson@mlj-llc.com

www.mlj-llc.com

Education – Dr. Michael L. Johnson

Ph.D. 1984, University of Kansas

M.A. 1977, University of Colorado

B.A. 1974, University of Colorado

Past Positions

Research Scientist, Center for Watershed Sciences, John Muir Institute of the Environment, 2008 – 2010

Adjunct Associate Professor, Department of Medicine and Epidemiology, School of Veterinary Medicine, 2004 - 2010

Associate Research Scientist, John Muir Institute of the Environment, 1998 – 2008

Director, Lead Campus Program in Ecotoxicology, UC Toxic Substances Research & Teaching Program 2000-2005

Associate Researcher, Department of Civil and Environmental Engineering, 1992 - 1998

Lecturer, Department of Environmental Toxicology, 1998-99

Lecturer, Department of Wildlife, Fish, and Conservation Biology, UC Davis, 1993 - 1995

Assistant Scientist, Kansas Biological Survey, 1991-1992

Adjunct Assistant Professor, Department of Systematics and Ecology, University of Kansas, 1989-1992

Research Associate, Kansas Biological Survey, 1988-1991

Postdoctoral Research Associate, Department of Systematics and Ecology, University of Kansas, 1987-1988

Lecturer, Department of Mathematics, University of Kansas, 1984-1987

Related Project /Experience

Study Title: Establishing cost efficient methods to measure nitrate movement beyond the root zone when using nutrient BMPs in California Specialty Crops

Project Abstract: This project was funded by a Specialty Crop Grant by the California Department of Food and Agriculture (CDFA) and was awarded to the Coalition of Urban and Rural Environmental Stewardship (CURES). Michael L. Johnson, LLC (MLJ-LLC) was a subcontractor to the project and implemented the monitoring design, data review and storage, data analysis and results write up. The project's main goal was to establish a reliable and repeatable scientific method to characterize the movement of nitrogen fertilizers beyond the plant root zone. After a literature review, the project focused on evaluating the ability of using an Automated Monitoring System (UMS) versus a traditional suction lysimeters system to collect water samples in cauliflower, lettuce and walnut fields below the root zone. Both methods were able to effectively collect water and nitrate concentrations varied across the fields and at different depths. Due to the lower expense of lysimeters, they were used in a field trial in two lettuce fields to evaluate the amount of nitrogen leaching past the root zone. One of the adjacent lettuce fields received the normal amount of nitrogen and the other received half that amount. The

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results of the study were affected by significant differences in permeability between the two fields. However, the results of the two year study on both methodology and management practice effectiveness have found that using a lysimeter system to characterize movement of nitrogen fertilizers past the root zone is both cost effective and reliable. The protocols used within the field trial on lettuce are being further refined based on the study results and will assist growers in both the Central Valley and Central Coast better understand the amount of nitrogen leaching past the root zone for specific crops.

Project Methods:

Samples were collected in 2014 to optimize the depths of sampling in the vegetable crops and develop a process for determining the number of instruments that are needed to adequately sample water moving past the root zone at a larger scale (part or all of a planting block depending on size). Sampling occurred in 2014 after initial storm events within Stockton, Salinas and Gonzales locations and continued during additional winter storms and irrigation events in 2014. To better understand variability in soil characteristics that can affect moisture content and water movement, hydraulic conductivity and/or soil texture analysis of soil samples were also conducted in 2014. The results from the additional winter sampling and analysis were then used to develop a field trial on lettuce utilizing lysimeters to measure the difference in nitrogen concentration in fields with different nitrogen management practices. The field trial found that the amount of nitrate present in the soil prior to planting did not differ between the two fields and therefore any differences in nitrate concentrations measured in the water moving past the root zone were due to the amount of nitrate applied during the crop cycle. However, the permeability between the two fields was found to be significantly different; one field had twice the hydraulic conductivity as the other. The field with the higher hydraulic conductivity received the lower amount of nitrate. The nitrate concentrations in the water samples collected below the root zone were twice as high in the field with the highest hydraulic conductivity even though half as much nitrate was applied. There were no differences in moisture content, crude protein, or total N content of the trimmed tissue or the Romaine heads between the two sides.

Grants and Contracts

University of California (All grants as Principle Investigator unless noted otherwise)
Identifying pharmaceuticals in the Sacramento River. State Water Resources Control Board
June 2007 – March 2011 (\$20,037)

Review of ammonia in the Delta. State Water Resources Control Board June 2008 – March 2010 (\$40,697)

Identifying pharmaceuticals in the Napa River and tributaries. Napa Sanitation District
November 2008 – June 2010 (\$75,000)

Pelagic Organism Decline. State Water Resources Control Board June 2008 – March 2010
(\$450,000)

QAPP development for permitting operations. California Urban Water Agency July 2008 – September 2008 (\$8,835)

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Identifying pharmaceuticals in Sonoma Creek and tributaries. Sonoma County Water Agency
April 2007 – June 2009 (\$75,000)

Regional Data Center – California Environmental Data Exchange Network. State Water
Resources Control Board May 2007 – present (\$299,500)

Evaluation of the toxicity of biodiesel fuels. California Air Resources Board June 2007 – June
2009 (\$185,000)

Effect of Light Brown Apple Moth pheromones on honey bees. California Department of Food
and Agriculture December 2007 – December 2009 (\$187,425)

Guidance Document and Recommendations on the Types of Scientific Information to be
Submitted by Applicants for California Fuels Environmental Multimedia Evaluations. California
Air Resources Board. June 2007 – May 2009 (\$55,110)

Phase II Continuation of Monitoring of Agricultural Drainage Water Quality in the Central
Valley of California. CAL EPA Water Control Board. December 2003 – June 2008 (\$2,337,837)

City of Ukiah Healthy Waterways Study. City of Ukiah. July 2006 – December 2008 (\$35,000)

Review & Assessment of Apalachee I BMPs and Monitoring Needs, Task 2. El Dorado County.
November 2004 - January 2009 (\$17,472)

Review & Assessment of Apalachee I BMPs and Monitoring Needs, Task 3. El Dorado County.
November 2004 – January 2005 (\$17,472)

Identification of Bacterial Sources for the East San Joaquin Water Quality Coalition. East San
Joaquin Water Quality Coalition. July 2006 – December 2006 (\$7,123)

Bacterial Source Identification Analysis. East San Joaquin Water Quality Coalition. April 2007 –
June 2008 (\$16,673)

Identification of Bacterial Sources for the Sacramento Valley Water Quality Coalition. July 2006
– December 2007 (\$6,600)

Lake County Healthy Waterways Study. Lake County. August 2005 – February 2008 (\$34,500)

Detection of Fecal Contaminants in Groundwater. Lake County. March 2007 – December 2008
(\$6,840)

Scientific Peer Review of Public Health Goal Documents. CAL EPA – Office of Environmental
Health Hazard Assessment. July 2005 – August 2005 (\$3,000)

Feather River PRISM. Coalition for Urban/Rural Environmental Stewardship. January 2005 –
January 2008 (\$70,000)

FREP Proposal for Nitrogen Management Practices in Processing Walnuts

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Feather River Prop 50 Monitoring and Modeling. California State Water Resources Board
November 2005 – December 2007 (\$143,331)

Identification of Bacterial Sources for the San Joaquin County & Delta Water Quality Coalition.
San Joaquin County and Delta Water Quality Coalition. July 2006 - December 2006 (\$7,300)

Tahoe Basin Toxicity Testing. California Department of Transportation October 2005 – May
2008 (\$6,281)

Total Maximum Daily Load Monitoring. State Water Resources Control Board March 2007 –
February 2008 (\$139,500)

Central Valley Bioassessment 2005-06. Central Valley Regional Water Quality Control Board,
December 2005 – December 2006 (\$276,048)

El Dorado County Department of Transportation Sampling and Analysis of Water Runoff.
Eldorado County Department of Transportation February 2004 – February 2008. (\$475,000)

Using a sensitive Japanese Medaka (*Oryzias latipes*) fish model for the detection of endocrine
disruptors in ground water. State Water Resources Control Board, June 2004 – May 2006
(\$238,000) (Co-PI, S. Teh PI)

Central Valley Bioassessment 2004-05. Central Valley Regional Water Quality Control Board,
April 2004 – June 2005 (\$228,000)

Using a sensitive Japanese Medaka (*Oryzias latipes*) fish model for endocrine disruptors
screening. U.S. Environmental Protection Agency, October 2003 – September 2006 (\$399,167)
(Co-PI, S. Teh PI)

Fire and fuels management, landscape dynamics, and fish and wildlife resources: study design
for integrated research on the Plumas and Lassen National Forests -- Small mammal distribution,
abundance, and habitat relations. USDA-Forest Service, 2002-2007. (\$1,604,000); (Co-PI, D.
Kelt PI)

TMDL monitoring of Central Valley Watersheds 2002-03. Central Valley Regional Quality
Control Board, December 2002 – August 2003 (\$340,147)

Review of Angora Meadows Monitoring Data. El Dorado County, March – May 2003 (\$2,061)

Ecotoxicology Lead Campus Program. UC Toxic Substances Research and Teaching Program,
June 2000 – June 2004 (\$1,266,594)

Central Valley Bioassessment 2003-04. Central Valley Regional Water Quality Control Board,
June 2003 – June 2004 (\$186,620)

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Review of Public Health Goals Draft Documents for 1,1,2,2-Tetrachloroethane, Chlorobenzene, Simazine, and 1,1-Dichloroethane. Office of Environmental Health Hazard Assessment, Cal EPA, December 1998 – January 2003. (\$6,000)

Review of SFBRWQCB Risk Based Screening Levels for Ecological Receptors. UC Berkeley, April 2003 – June 2003 (\$2,000)

Water quality modeling for the Shasta River dissolved oxygen and temperature TMDLs. North Coast Regional Water Quality Control Board, December 2003 – December 2004, (\$115,000) Co-PI, (J. Quinn, PI)

TMDL monitoring of Central Valley Watersheds 2003-04. Central Valley Regional Water Quality Control Board, November 2003 – March 2004, (\$259,973)

Statewide toxicity testing research project. California Department of Transportation. June 2000 – June 2003 (\$1,710,000)

Simplex modeling of an urban watershed. Vallejo Sanitation and Flood Control District. August 2000 – August 2001 (\$29,000)

Perchlorate exposure in drinking water. California Department of Health Services. (Co-PI, G. Fogg, P.I.) June 1999 – September 2001 (\$222,603)

FREP project. California Department of Food and Agriculture, February 2000 – March 2000 (\$4,000)

Estrogenicity of selected herbicides and adjuvants. California Department of Transportation. October 1998 – June 2002 (\$241,627)

Simplex modeling of an urban watershed. Fairfield-Suisun Sewer District. December 2000 – December 2001 (\$10,000)

MTBE analysis in California. University of California Toxic Substances Research and Teaching Program (Co-PI). January 1998 - October 1998 (\$220,000)

TMDL analysis of North Coast watersheds (North Coast River Loading Study). California Department of Transportation, July 1997-June 2002 (\$1,541,173)

The impact of stormwater runoff on North Coast rivers (Small Stream Crossing Study). California Department of Transportation, November 1997-June 2002 (\$1,820,144)

San Pablo Bay National Wildlife Refuge vegetation monitoring plan. California Department of Transportation, July 1997-June 2002 (\$419,250)

Small mammal survey of the Alhambra Creek Wetlands. California Department of Transportation, September 1997-October 1997 (\$12,000)

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Baseline vegetation survey of the East San Pablo Bay Unit of the San Pablo Bay National Wildlife Refuge. California Department of Transportation, July 1996-March 1997 (\$50,000)

An integrated assessment of a linked wetland-nearshore estuarine ecosystem at Mare Island Naval Shipyard. University of California Toxic Substances Research and Teaching Program, July 1996-June 1997 (\$363,000)

An integrated assessment of a linked wetland-nearshore estuarine ecosystem at Mare Island Naval Shipyard. University of California Toxic Substances Research and Teaching Program, July 1995-June 1996 (\$160,000)

An integrated approach to assessing water management options in a major watershed: Extending a hydrodynamic-water quality model to include biological and politico-economic components (Co-PI). U.S. Environmental Protection Agency (EPA-NSF), October 1996-September 1999 (\$1,292,627)

Development of an ecological risk assessment model. Year 2. California Environmental Protection Agency, July 1995 - June 1996 (\$40,000)

Salt marsh hydrology and mitigation of flooding. California Department of Transportation, October 1995 - June 1996 (\$50,000)

Salt marsh modeling. National Biological Survey, November 1994 - October 1995 (\$59,325)

UC Davis Environmental Education Partnership (UCDEEP). (Co-PI) Department of Defense, October 1994 - September 1995 (\$1,660,207)

An integrated ecological assessment of three wetlands sites at Mare Island Naval Shipyard. University of California Toxic Substances Research and Teaching Program, July 1994 - June 1996 (\$79,453)

Development of an ecological risk assessment model and symposia. California Environmental Protection Agency, July 1994 - June 1995 (\$250,000)

A regionalized assessment of the influences of rural nonpoint source pollution on the ecological integrity of stream ecosystems and evaluation of associated pollution control management:
Data management and data analysis (Year 2). Subcontract to University of Kansas, June 1993 - June 1994 (\$23,000)

Hydrodynamic modeling of Pt. Mugu Lagoon. U.S. Fish and Wildlife Service, August 1993 - December 1993 (\$5,000)

Feasibility study of alternate wetland restoration plans for the Napa Marsh Unit of the San Pablo Bay National Wildlife Refuge. U.S. Fish and Wildlife Service, January 1993 - December 1994 (\$85,286)

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A regionalized assessment of the influences of rural nonpoint source pollution on the ecological integrity of stream ecosystems and evaluation of associated pollution control management.

Phase I. Selection of watersheds. U.S. EPA, Region IX, August 1992 - June 1993 (\$29,000)

An assessment of the effects of nonpoint source pollution on the biotic integrity of Walnut Creek, and the role of riparian vegetation in mitigating nonpoint source pollution: Data management and data analysis. Subcontract to University of Kansas, October 1992 - September 1995 (\$35,443)

A regionalized assessment of the influences of rural nonpoint source pollution on the ecological integrity of stream ecosystems and evaluation of associated pollution control management:

Data management and data analysis (Year 1). Subcontract from the University of Kansas, June 1992 - June 1993 (\$23,000)

University of Kansas

Data for validation of EPA modeling. U.S. EPA - ERL Duluth, August 1990 - March 1991 (\$7500)

A regionalized assessment of the influences of rural nonpoint source pollution on the ecological integrity of stream ecosystems and evaluation of associated pollution control management (Year 1). U.S. EPA, June 1991 - June 1992 (\$1,250,000)

A regionalized assessment of the influences of rural nonpoint source pollution on the ecological integrity of stream ecosystems and evaluation of associated pollution control management (Year 2). U.S. EPA, June 1992 - June 1993 (\$1,450,000)

An assessment of the effects of nonpoint source pollution on the biotic integrity of Walnut Creek, and the role of riparian vegetation in mitigating nonpoint source pollution. U.S. EPA, August 1992 - July 1995 (\$325,000)

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Gaines, M. S. and **M. L. Johnson**. 1982. Home range size and population dynamics in the prairie vole, *Microtus ochrogaster*. *Oikos* 39:63-70.

Abdellatif, E., K. B. Armitage, M. S. Gaines, and **M. L. Johnson**. 1982. The effect of watering on a prairie vole population. *Acta Theriologica* 27:243-255.

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Appendix II: Cooperators

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Appendix III: Supporters